Space Weather Technical Forecast

Issued on Thursday, 25 April 2024 at 12:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further M-class flares (R1/R2 blackouts) expected. Chance of isolated G1/Minor Storm intervals from CME or HSS effects Days 2-3 (26-27 Apr). Chance of Active fluence Days 1-2 (25-26 Apr).

Solar Activity: Activity is currently Moderate with several M-class flares observed in the past 24 hours. The largest of these reached M2.0 at 24/2259UTC from the large complex that straddles the southwest limb. There are currently seventeen sunspot regions on the visible disc, two of which are unnumbered. This includes a broad cluster of regions located in the southwest which includes AR3638, AR3645, AR3647 and AR3643. These regions carry a large percentage of the current flare risk, with the spots magnetically connected and a large amount of flux associated with them, suggesting a potential for X-class flares. However, this group is becoming increasingly difficult to analyse due to its location. AR3648 (Eai/Beta-Gamma-Delta), in the northwest is another notable region on the disc. It has seen consolidation of its central portion and maintains a weakly defined delta region. AR3654 (Eai/Beta-Gamma) in the southeast, is one of the largest and most complex regions on the disc and has seen proliferation of some minor spot.

Multiple CMEs have been observed in coronagraph imagery over the previous 24hrs, with some potential for a glancing blow to be observed at Earth. A prominence eruption across the eastern limb at 25/1100UTC has produced a CME but this is not expected to have an Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar winds observed by ACE and DSCOVR at L1 were at background levels. Wind speeds have gradually declined from 380km/s and are currently around 320 km/s. Density was below average throughout. The Interplanetary Magnetic Field, Bt, was weak at 5nT or below. The north-south component, Bz, has varied weakly between +3/-4nT but has been predominantly negative since 25/0500UTC. Phi angle was initially positive (away from the Sun), switching to mostly negative (towards the Sun) at 24/1530 UTC. The direction has weakly fluctuated since around 22/2300 UTC. Geomagnetic activity was Quiet (Kp 0-1).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed at GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed at GOES16 was generally Moderate, but has been High since 25/1045UTC with a peak of 1670 pfu. The associated 24-hour fluence remained below Active (1e8 integrated flux), but with a rising trend, reaching a peak during the period of 6.33xe7 integrated pfu at 25/1200 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected to continue, with a very slight chance of isolated X-class flares. The cluster of regions in the southwest will fully rotate off the disc late on Day 2 (26 Apr). The flare risk is then expected to decline during Day 3 (27 Apr) and Day 4 (28 Apr) as these regions rotate well away from the west limb. There remains a flare risk from other regions on the visible disc however, with the chance of M-flares continuing throughout.

Solar Wind / Geomagnetic Activity: There is a risk of CMEs passing close to Earth throughout the period, largely missing ahead and to the south of our orbit. The greatest potential for any

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impacts is thought likely to be later Day 2 into early Day 3 (26-27 Apr). Solar winds are currently at background levels with enhancement from coronal hole high speed streams expected to connect during Days 2-3. Contributions most likely to come from CH27/+ and CH30/+, with additional enhancement possible from CH29/+ late Day 3. The combined contributions are likely to result in an increase in wind speeds during this period, perhaps reaching 500-550 km/s.

Geomagnetic activity is likely to be Quiet to Unsettled (Kp 0-3) at first. This has the potential to become Unsettled to Active (Kp 3-4) with a chance Days 2-3 (26-27 Apr) of G1/Minor Storm (Kp 5) intervals, either under CME or high speed stream influence, or perhaps a combination of both. The risk should decline into Day 4 (28 Apr).

Energetic Particles / Solar Radiation: High energy proton flux is likely to remain at background levels, but with a slight chance of reaching the S1/Minor Radiation Storm threshold throughout. High energy electron flux as observed by GOES16 is likely to peak at High levels at the start of the period, before seeing diurnal return to Moderate. Flux levels are likely to be suppressed by anticipated CME and HSS arrivals during the period, perhaps recovering later Day 4 (28 Apr). The associated 24-hour electron fluence has a chance of reaching Active (1e8 integrated pfu) on Days 1-2 (25-26 Apr), then likely declining.

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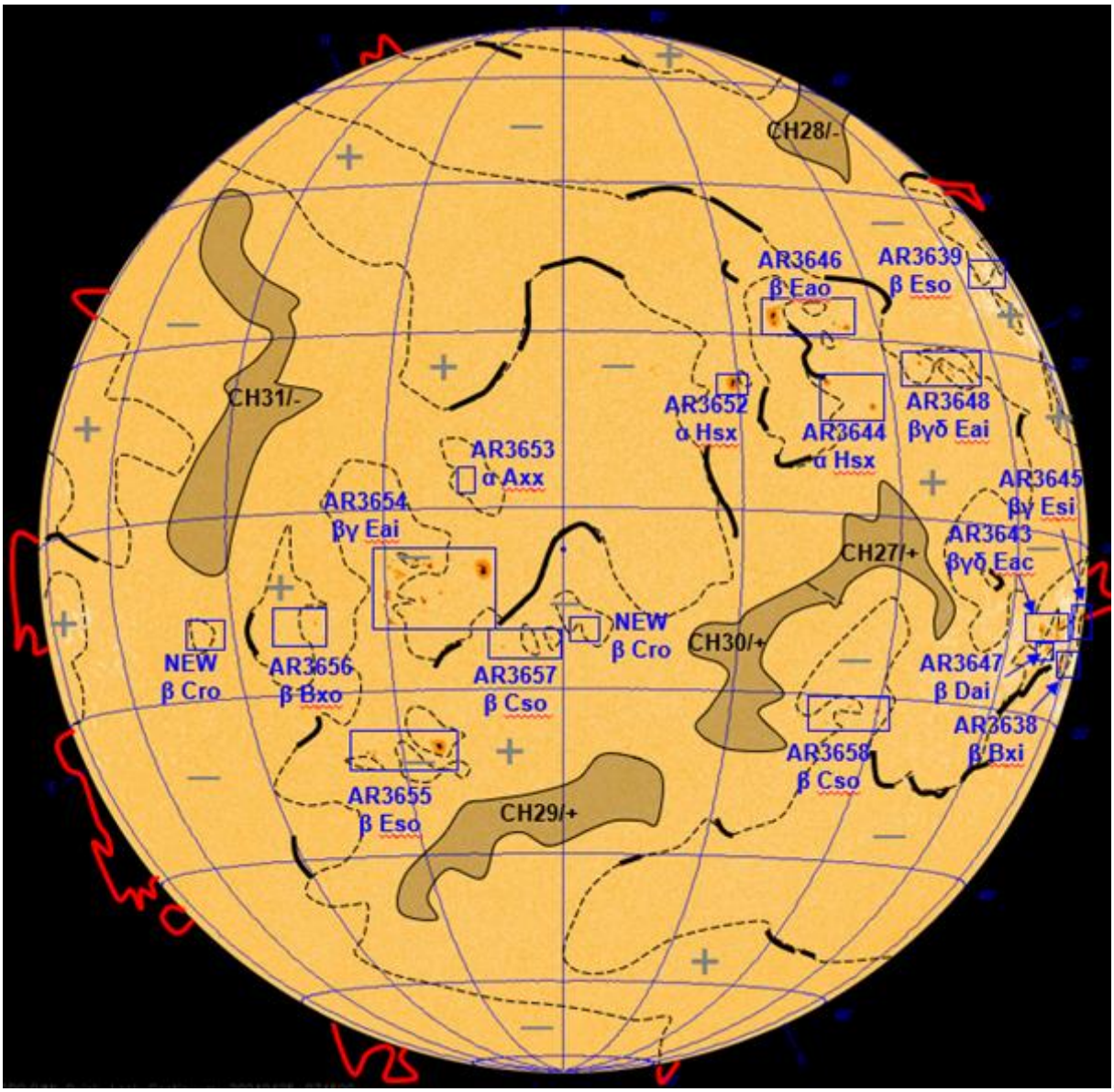
Figure 1. Solar Analysis Valid 25/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Multiple CMEs have been observed in recent days, most of these associated with eruptions originating from the complex sunspot region that lies across the southwest limb. Analysis suggests there is a risk of CMEs passing close to Earth throughout the period, largely missing ahead and to the south. For the most part these CMEs are unlikely to give significant impacts, but the greatest potential for any impacts is thought likely to be later Day 2, through the UTC night, and into Day 3 (26-27 Apr). Other CMEs observed lifting off the disc are not thought to be Earth-directed.

Solar winds are currently at background conditions, around 320 km/s. The coronal hole feature in the western disc, combines both CH27/+ and CH30/+. These are persistent features, with the leading edge perhaps a little ahead of the previous rotation. They are likely to bring an increase in wind speeds during this period to Slightly Elevated levels, most probably during Day 2, with wind speeds perhaps reaching Elevated levels of 500-550 km/s based on the previous rotation. However, the polarity of both of these coronal holes is positive, which is less favoured for geomagnetic connection at this time of year. CH29/+ in the south central disc may also weakly contribute towards solar wind enhancement Day 3 (27 Mar). Wind speeds are projected to return towards background through Day 4 (28 Apr). Enlil is currently too slow to connect to the CH27/+ HSS, but is otherwise considered as providing a reasonable steer. SWPM is providing good guidance to forecast wind speeds, although DSCOVR is currently reading strengths closer to 460 km/s which are not accepted.

Overall, geomagnetic activity is likely to be Quiet or Unsettled (Kp 0-3) at first. Activity may then become Unsettled to Active (Kp 3-4) from later Day 2 (26 Apr). There is the potential for the high speed stream and CME arrivals to occur concurrently, with the combined geomagnetic effects reflected in the chance of G1/Minor Geomagnetic Storm (Kp 5) intervals Days 2-3. The risk should decline into Day 4 (28 Apr).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	15	30	25	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Multiple CMEs mostly associated with the complex sunspot region in the southwest have been observed in recent days, with the potential for one or more of these to glance Earth during this period.

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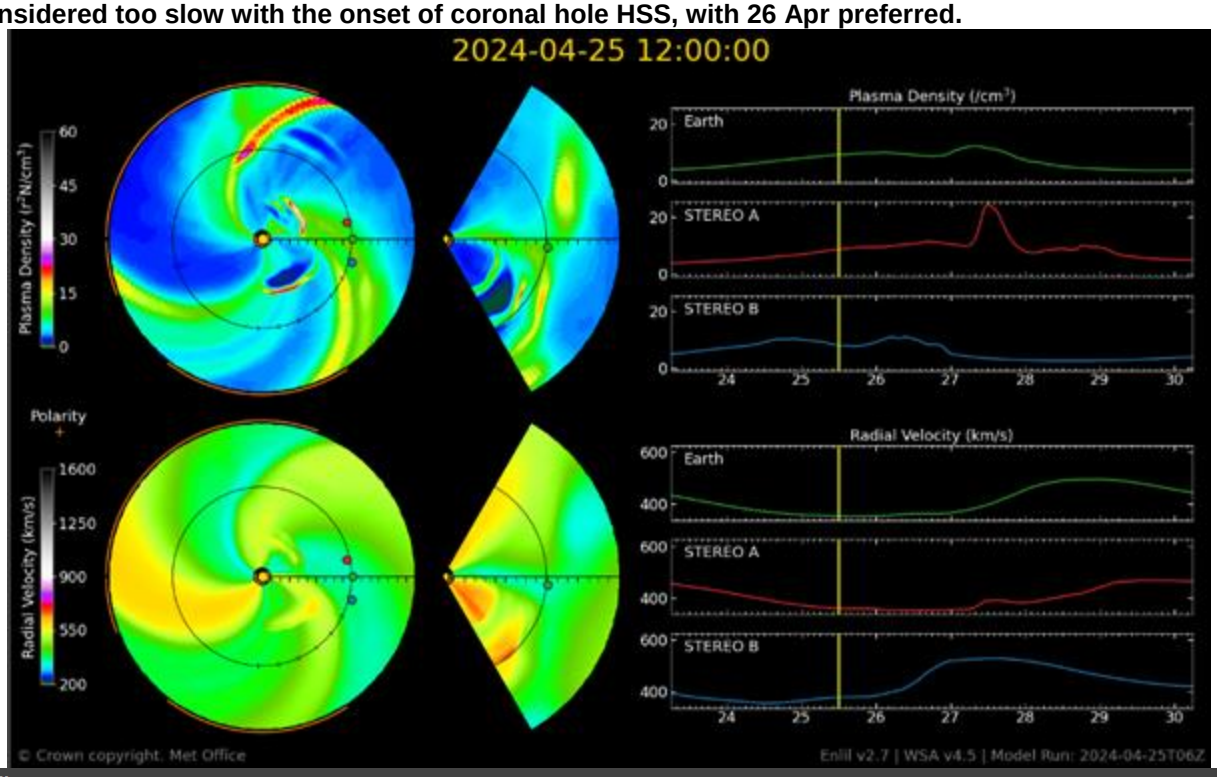
Figure 2: MOSWOC Enlil and ensemble, showing the potential for CME glancing blows. Enlil considered too slow with the onset of coronal hole HSS, with 26 Apr preferred.



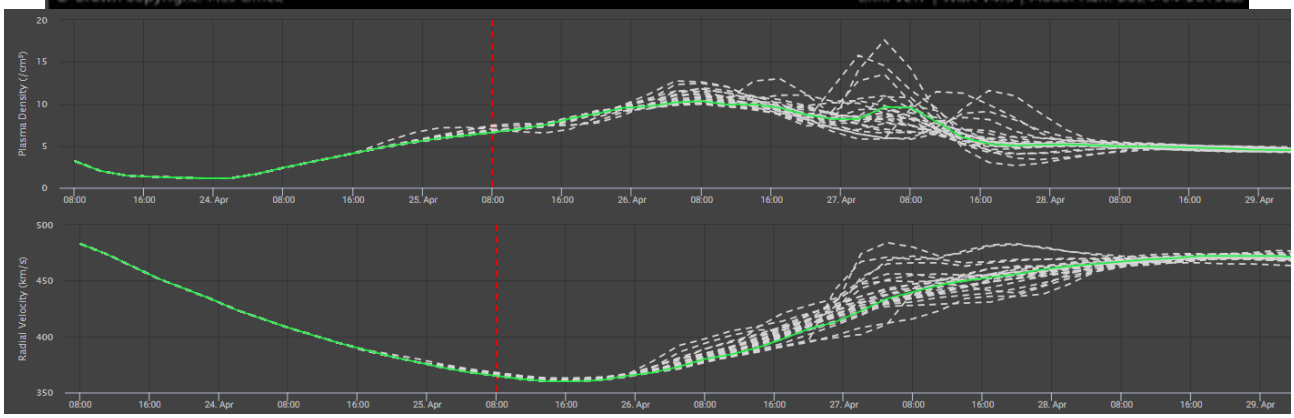
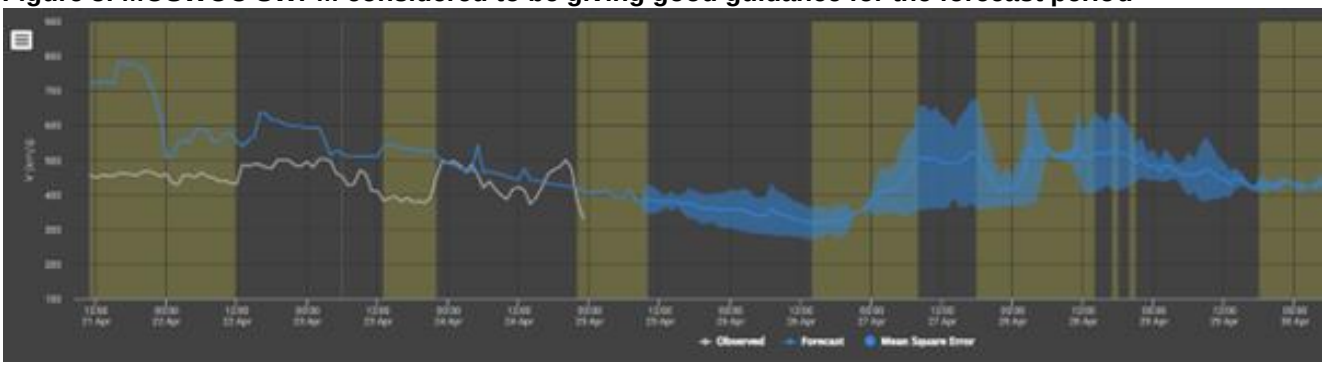


Figure 3: MOSWOC SWPM considered to be giving good guidance for the forecast period



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Radio Blackouts - X-Ray Flares:

There are currently seventeen sunspot regions on the visible disc. This includes a broad cluster of regions in the southwest which includes AR3638, AR3645, AR3647 and AR3643. These regions carry a large percentage of the current flare risk, with the spots magnetically connected and a large amount of flux associated with them, suggesting a potential for X-class flares. However, with this group's location across the western limb it is becoming increasingly difficult to analyse with the regions maintaining their previous classification as a result.

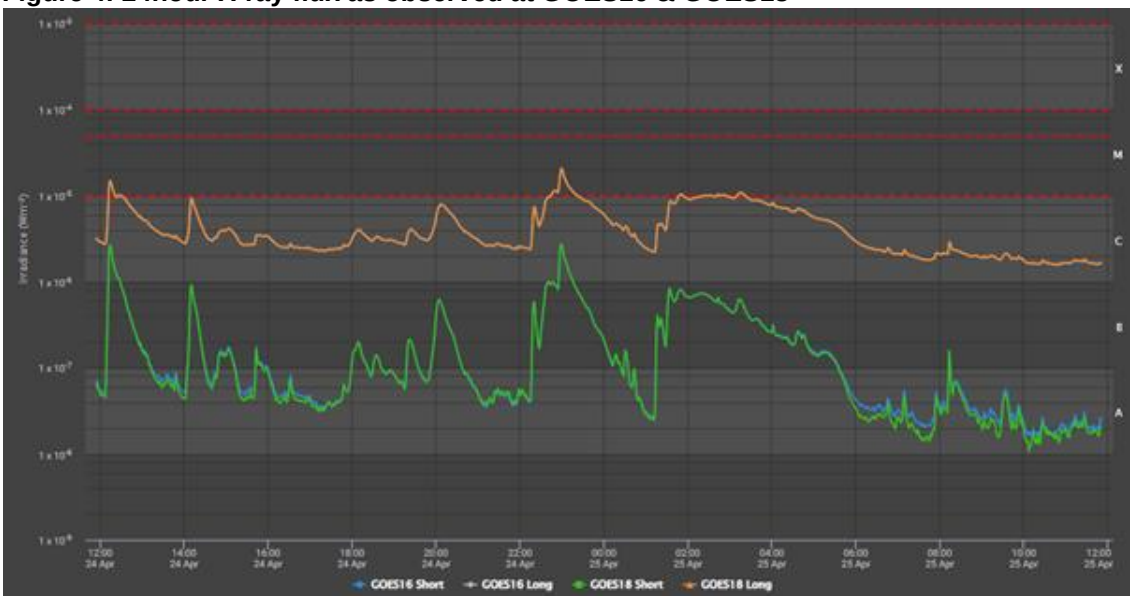
AR3654 (Eai/Beta-Gamma) in the southeast disc, is a developing region of moderate complexity. Elsewhere, AR3648, in the northwest, has shown consolidation of its central portion and maintains a weakly defined delta region. There is a faint region of plage of opposite polarity to the rear of AR3652 (Hsx/Alpha), however the group remains unipolar for analysis at this stage. The other regions are largely small and simple, although many have shown some slight signs of development over the past few hours.

Moderate activity is expected Days 1-3 (25-27 Apr), with a slight chance of isolated X-class flares. The cluster of regions in the southwest will start to rotate over the western limb late Day 1 (25 Apr), finally rotating off late on Day 2 (26 Apr). The flare risk is then expected to decline during Day 3 (27 Apr) as these regions rotate well away from the west limb.

With no significant returning regions are expected during the period, although far-sided helioseismic imaging would suggest a returning region may emerge late Day 3 (27 Apr) or Day 4 (28 Apr). Overall, a general reduction in the flare risk is indicated by Day 4 (28 Apr).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	75	60	40
Very Active	R3 to R5 X Class	No	15	15	10	5

Figure 4: 24hour X-ray flux as observed at GOES16 & GOES18



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Solar Radiation Storms - (High Energy Protons):
High energy proton flux as observed by GOES18 has persisted at background levels. There remains a slight chance of an increase in proton flux, with the cluster of sunspots in the southwest disc in a good location to give a proton enhancement at Earth. This brings a slight chance of reaching the S1/Minor Solar Radiation Storm level throughout the period. Whilst the complex fully rotates off the disc by the end of Day 2 (26 Apr), the risk of a proton enhancement will remain through the whole of this period until the cluster is well beyond the west limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):
High energy electron flux as observed by GOES16 has been rising over the past few days and is currently at High levels (since 25/1045) with a peak so far of 1067pfu at 25/1050UTC. This is likely as a response to the CME arrival and HSS onset that occurred during the past week. Now solar winds have returned to background levels, a further slight increase in flux is possible Days 1-2 (25-26 Apr) with a diurnal peak at High. This is only moderate confidence however. The arrival of any CMEs, alongside HSS arrivals most likely on Day 2 (26 Apr), is expected to suppress electron flux once again and bring it near to background levels. Any potential increase due to the upcoming HSS and/or CME effects is unlikely to occur until the very end of, or beyond the end of this period.

The associated 24 hour electron fluence is expected to continue on an increasing trend through Days 1-2 (25-26 Apr), with a chance of reaching Active. The fluence is then likely to follow a sharp declining trend once we see the arrival of coronal hole HSSs, and/or any CME arrival. MOSWOC REFM is suggesting a declining trend, but is perhaps a little too fast to bring fluence levels down.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	25	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 5: Electron flux trace as observed at GOES16 showing current High levels.

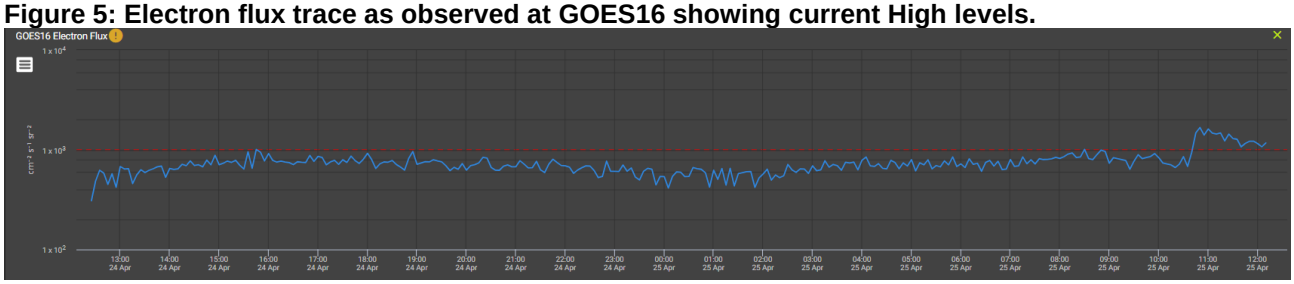
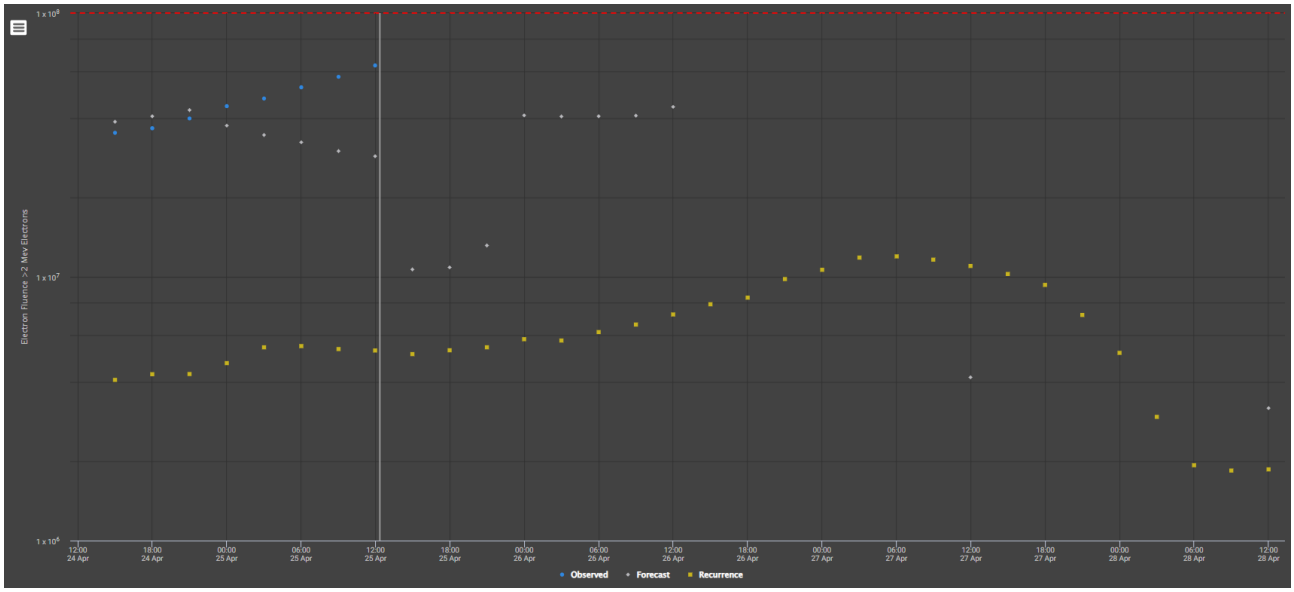


Figure 6: MOSWOC REFM showing an increase followed by a declining trend, which is thought to be too sharp with fluence most probably remaining higher for another day before declining.



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